



**Building Safety Division**

# **Best Practices Manual**

- **Footings & Foundations**
  - **Drainage**
  - **Compaction**



# **Best Practices Manual**

## **Footings & Foundations**

- Drainage**
- Compaction**

The Building Code requires that foundations be designed according to the soils on site; that proper drainage be provide; and that fill material be compacted. It is in the best interest of owners and builders to have the knowledge to make educated decisions. The purpose of this manual is to further reduce the incidence of foundation issues in Fayetteville and to eliminate remedial work during construction so that work may continue at a normal pace.

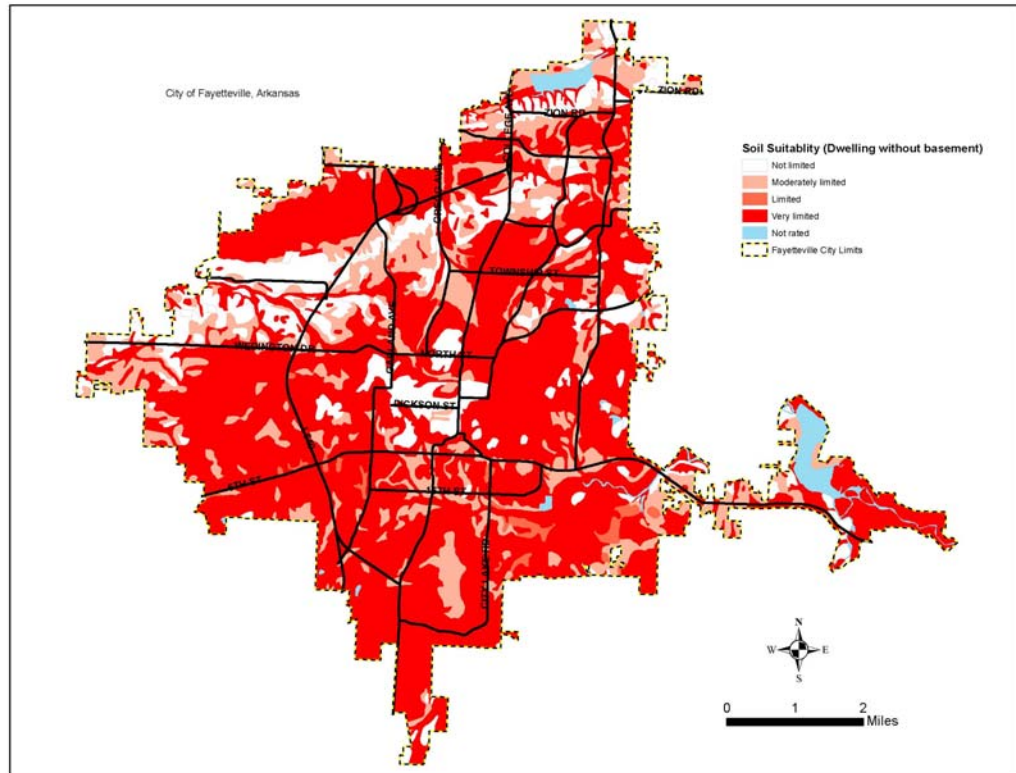
Many soils in Fayetteville are problematic due to the high rate of expansion and contraction caused by naturally occurring clays.

The Code often requires the services of a design professional or foundation specialist to determine the conditions of the soils and provide foundation design.

# Footings & Foundations: Soils

The Code requires that foundations “shall be capable of accommodating all loads and transmitting the resulting loads to the supporting soil.”

Problematic Soils are common in Fayetteville.

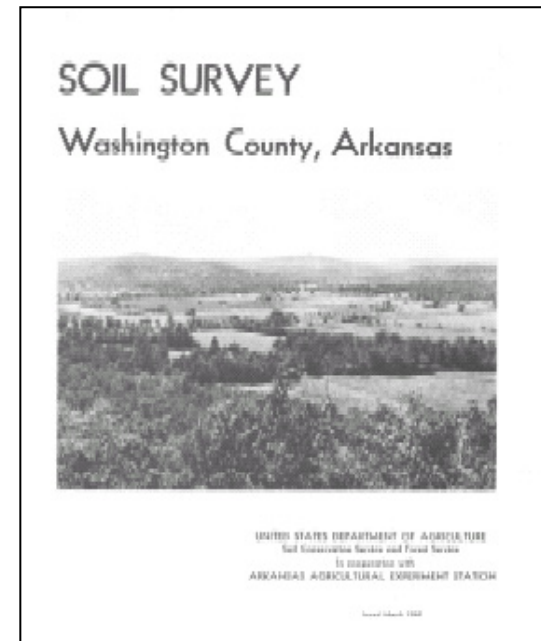
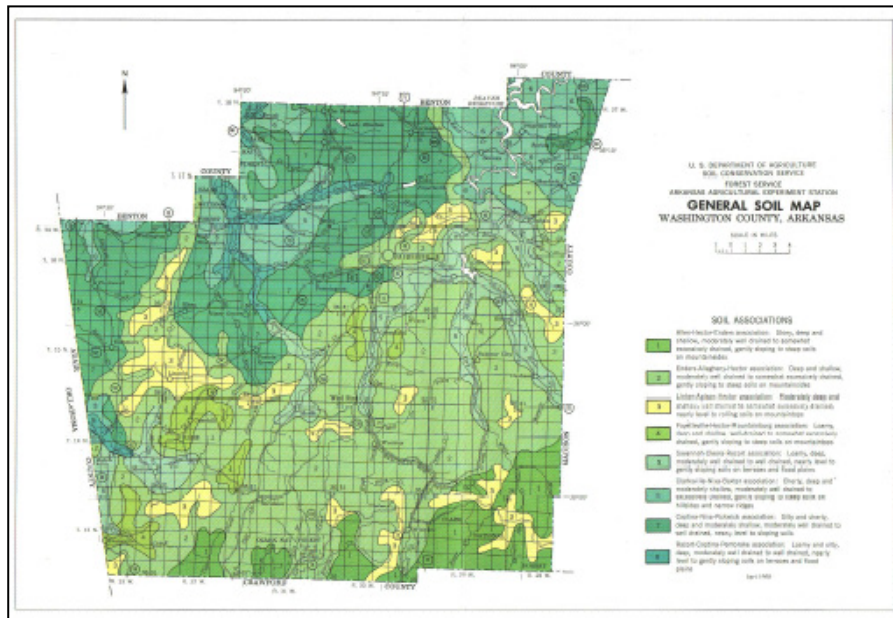


This Map shows the extent of these soils and is available in our office or on-line at:

[www.accessfayetteville.org](http://www.accessfayetteville.org)

# Footings & Foundations: Soils

Problem soils are usually related to clay soils that are classified as either CL, CH or MH (This includes all Enders soils and possibly 75% of the soils in Fayetteville). The best resource for general soil conditions is the Washington County Soil Survey.

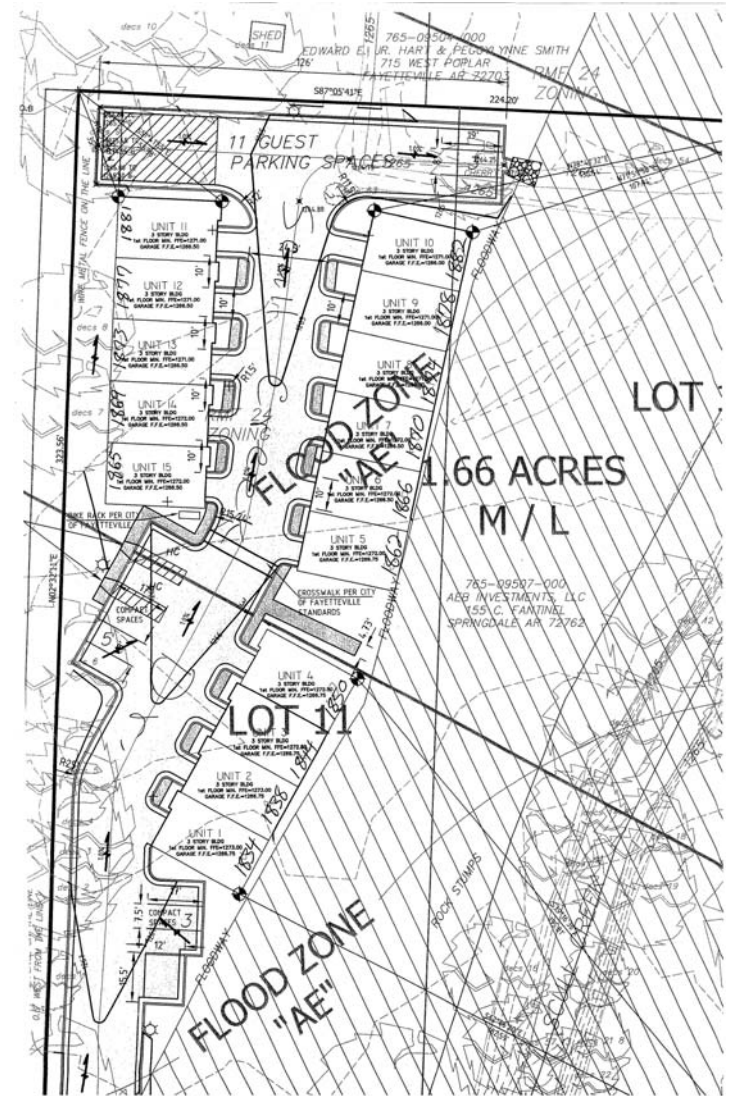


This publication is available at  
our office and on-line at:  
[www.accessfayetteville.org](http://www.accessfayetteville.org).

# Footings & Foundations: Soils

Developers are required to submit a drainage plan that shows the soil types located in the plat.

Ask the developer for a copy of the drainage plan to help identify soils found in your area.



# Footings & Foundations: Soils

If there is any question about the suitability of the soil, hire a professional soils specialist, geotechnical engineer or foundation specialist to evaluate site conditions and make recommendations.



# Footings & Foundations: Soils

It is the responsibility of the contractor to make sure the construction meets or exceeds the minimum Building Code requirements.

City inspectors do not perform tests to determine when a soil investigation is required.

There are easy, on site tests that owners or contractors can perform if they suspect problematic soils may be present.

Although these self tests are not conclusive, they can help decide when to call a professional.



The first step is to dig a test hole.

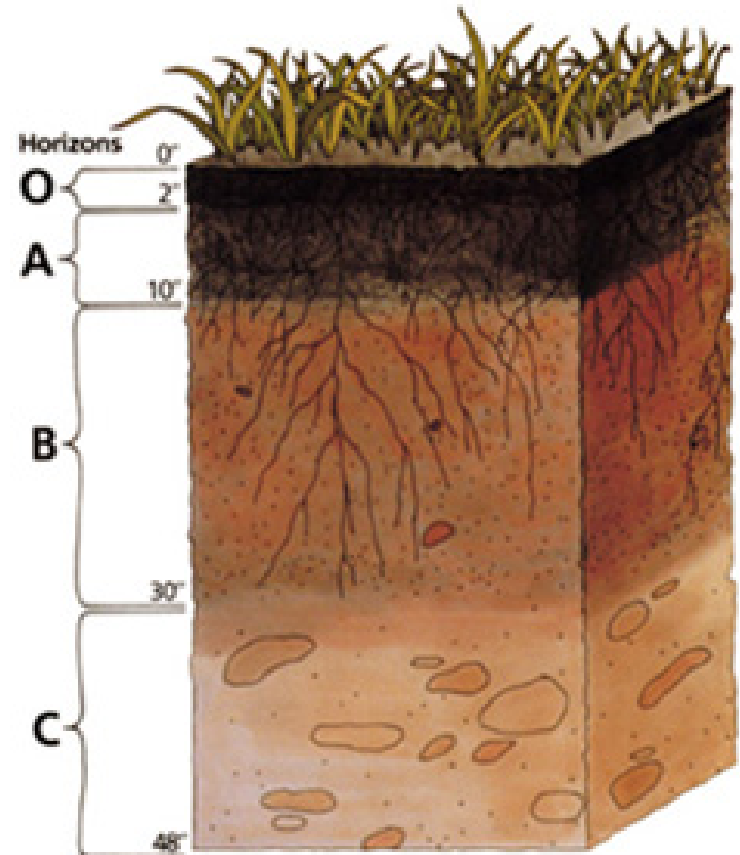


# Footings & Foundations: Soils

Compare the walls of the excavation to what you expected to find using the soils map. Keep in mind that the soils in our area are often mixed together and can vary on the same site.

This example shows the layers (horizons) of the soils. All foundations must be placed below the root zone (B).

Look carefully at the soil that will be supporting the structure. Is it red or grey/white when wet? Then its most likely an expansive clay.



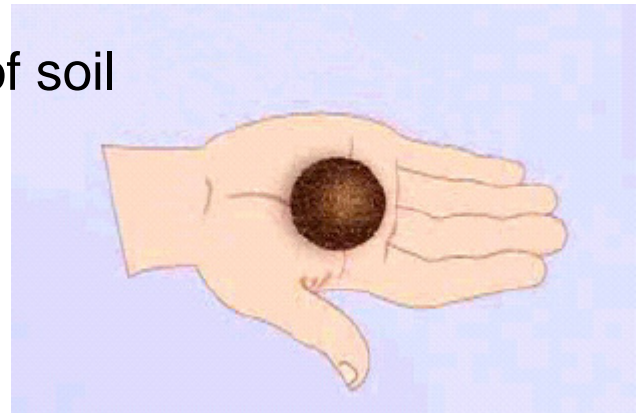
# Footings & Foundations: Soils

Expansion and Contraction is related to the PI (plasticity index). The Code defines expansive as soils with a “Plasticity Index (PI) of 15 or greater, determined in accordance with ASTM D 4318.” Expansive soils require a design professional or foundation specialist.

Don't be fooled by dry soil conditions. Dry clay is very hard. That's why it's important to mix water with a sample of soil to determine it's properties.

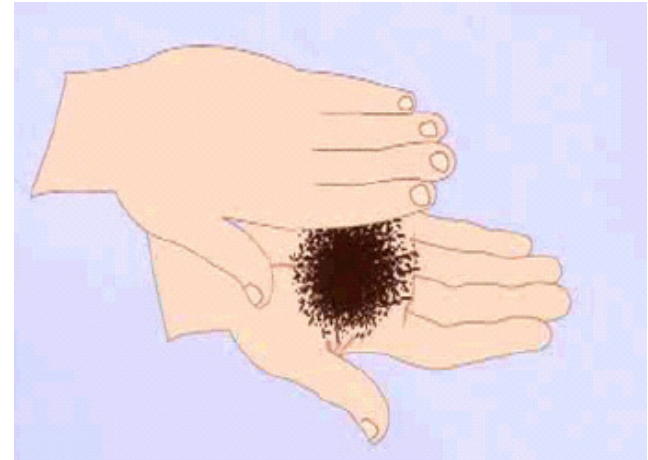
A common field test is to take a sample of soil from the bottom of the footing and wet it.

Then, roll it into a ball.



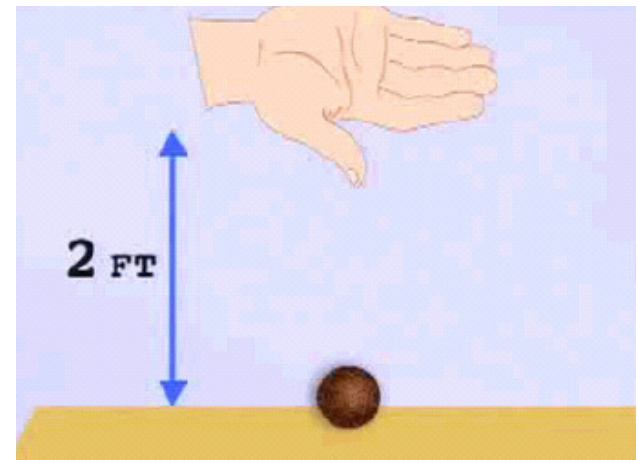
# Footings & Foundations: Soils

If the ball crumbles apart then the soil has low plasticity and will not expand or contract with changes in moisture.



If the ball stays together; drop it to the ground. If it falls apart then the soil is questionable and a specialist should be consulted.

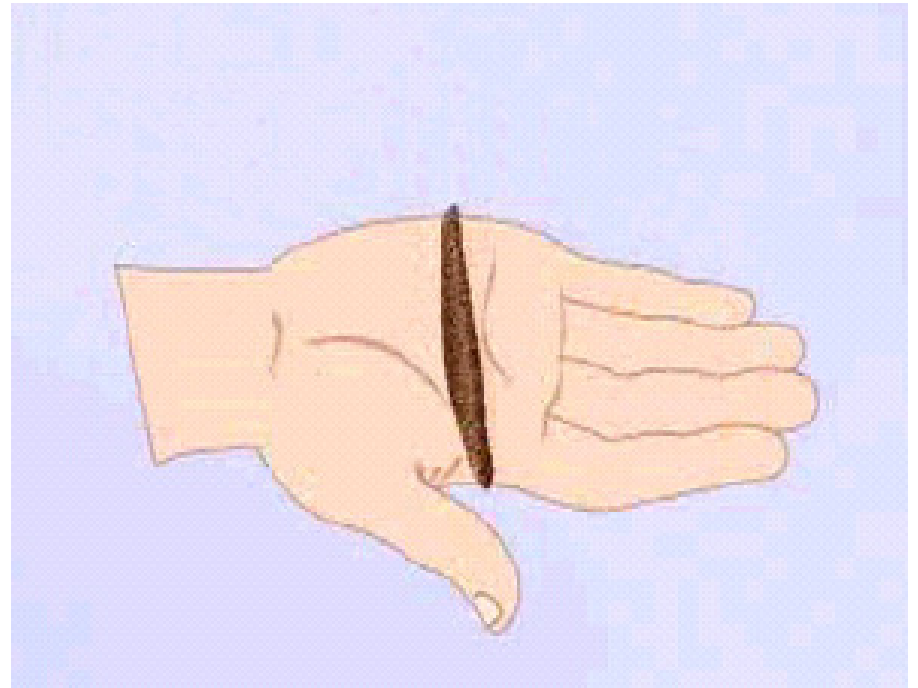
If the ball stays together when it is dropped then the soil is expansive and will require a specialist.



# Footings & Foundations: Soils

Another test is to roll the wet soil into a pencil shape about  $\frac{1}{4}$ " diameter.

If the pencil can be formed without breaking then consult a specialist.



# Footings & Foundations: Soils & Special Systems

The Building Code requires that “In areas likely to have expansive, compressible, shifting or other unknown soil characteristics, the building official shall determine whether to require a soil test to determine the soil's characteristics at a particular location. This test shall be made by an approved agency using an approved method.”

This means it's required to determine what type of foundation system is suitable for the soils present.

There are many designs and remedies for problematic soils. These are a few of the most common.

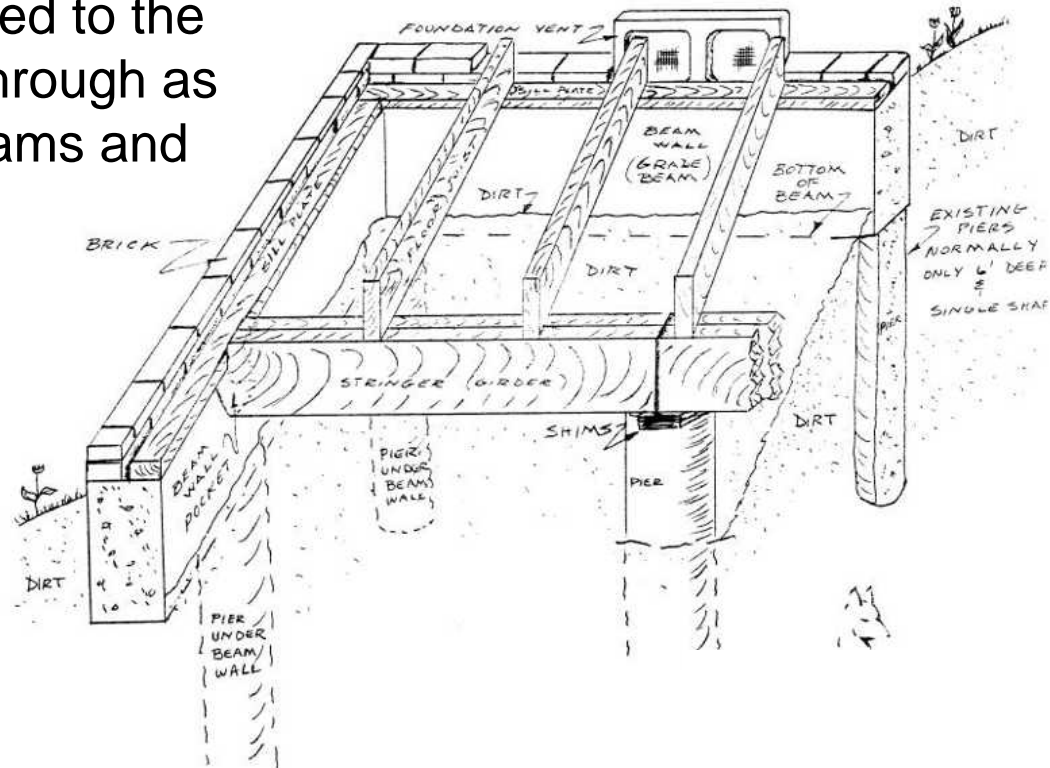
# Footings & Foundations: Special Systems

Design professionals often specify a special foundation system.

## Pier and Beam system:

## Requires professional design.

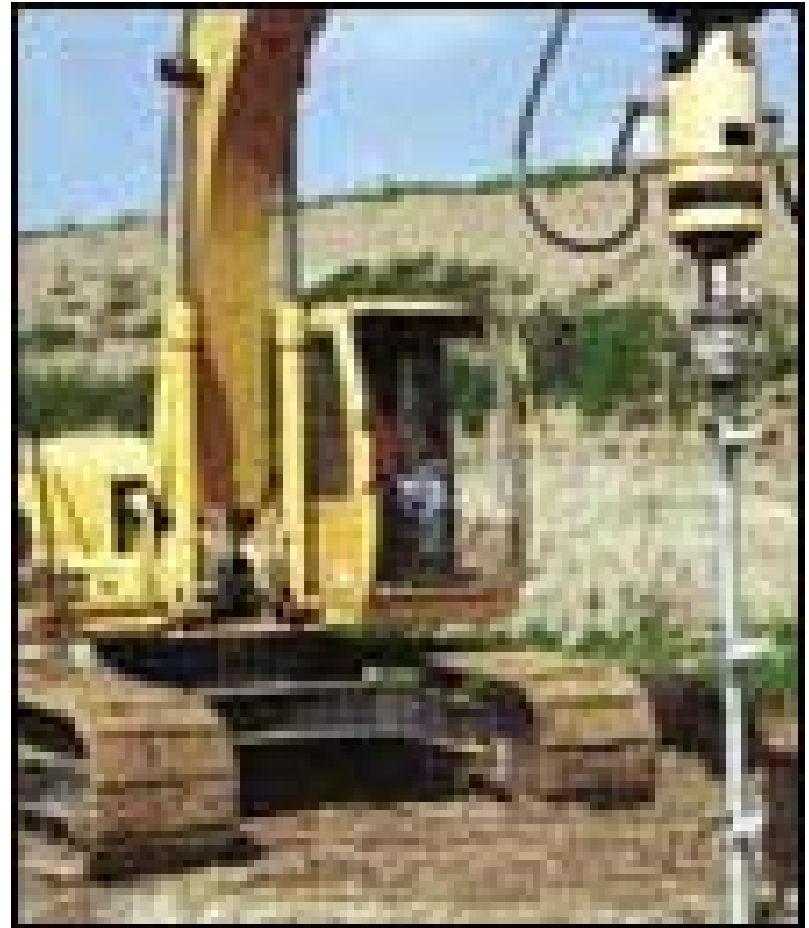
All loads are transmitted to the underlying strata through a series of grade beams and drilled piers.



# Footings & Foundations: Special Systems

Helical pier system:

Requires professional design and works similar to drilled pier system except that grade beams are supported by steel piers.

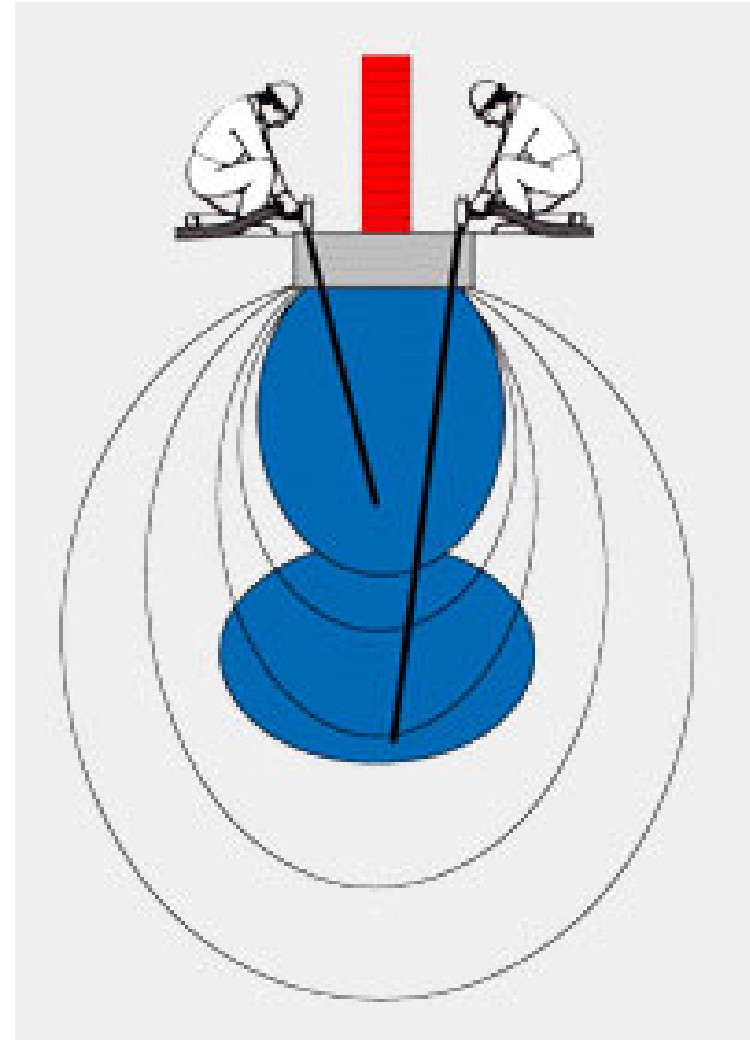


# Footings & Foundations: Special Systems

## Soil Stabilization Systems:

Utilizes expanding chemicals to replace voids and water in the soils. Used primarily in industrial applications.

Many other methods and systems are available. Consult a foundation specialist or design professional.

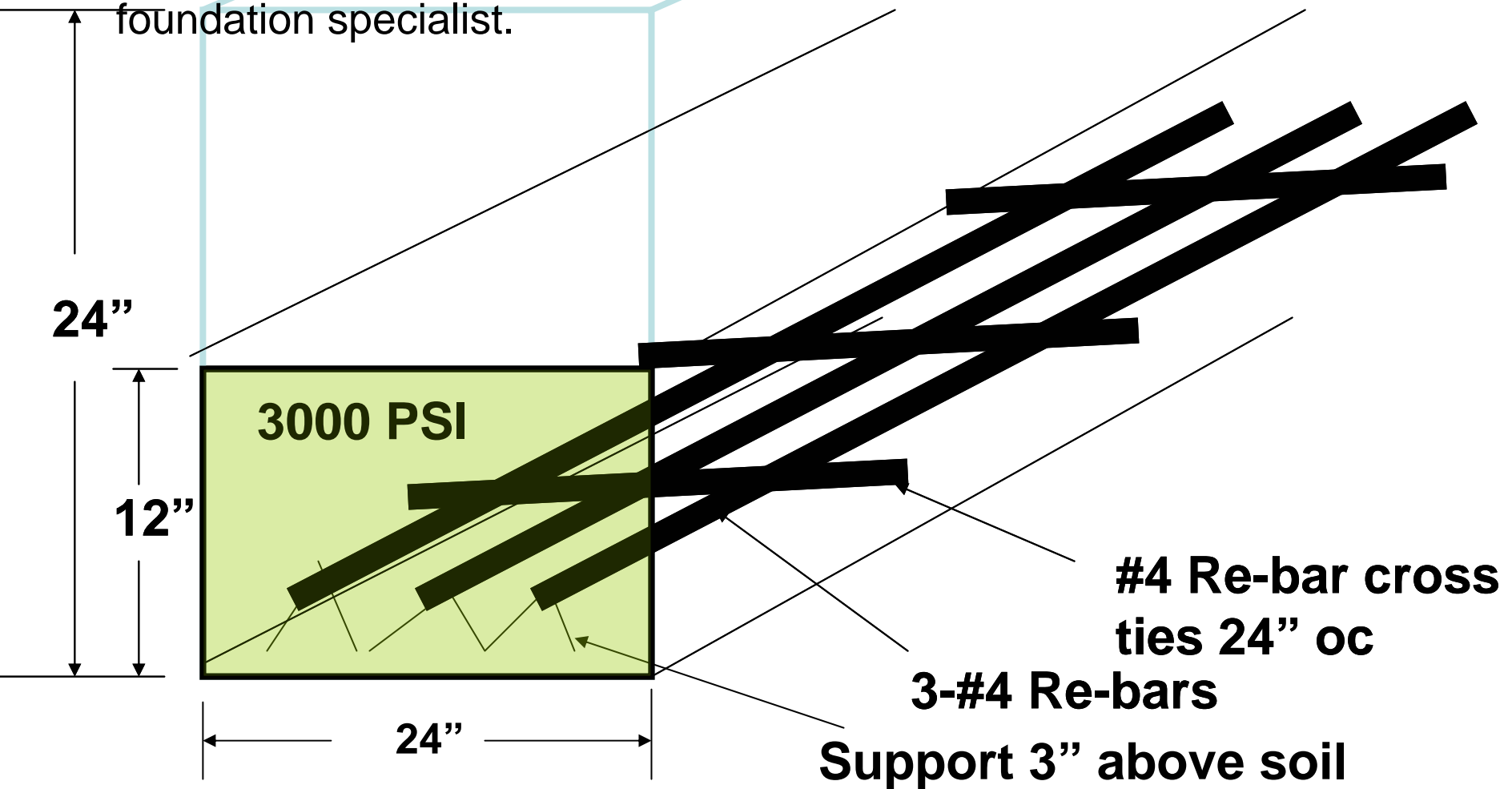




# Footings & Foundations:

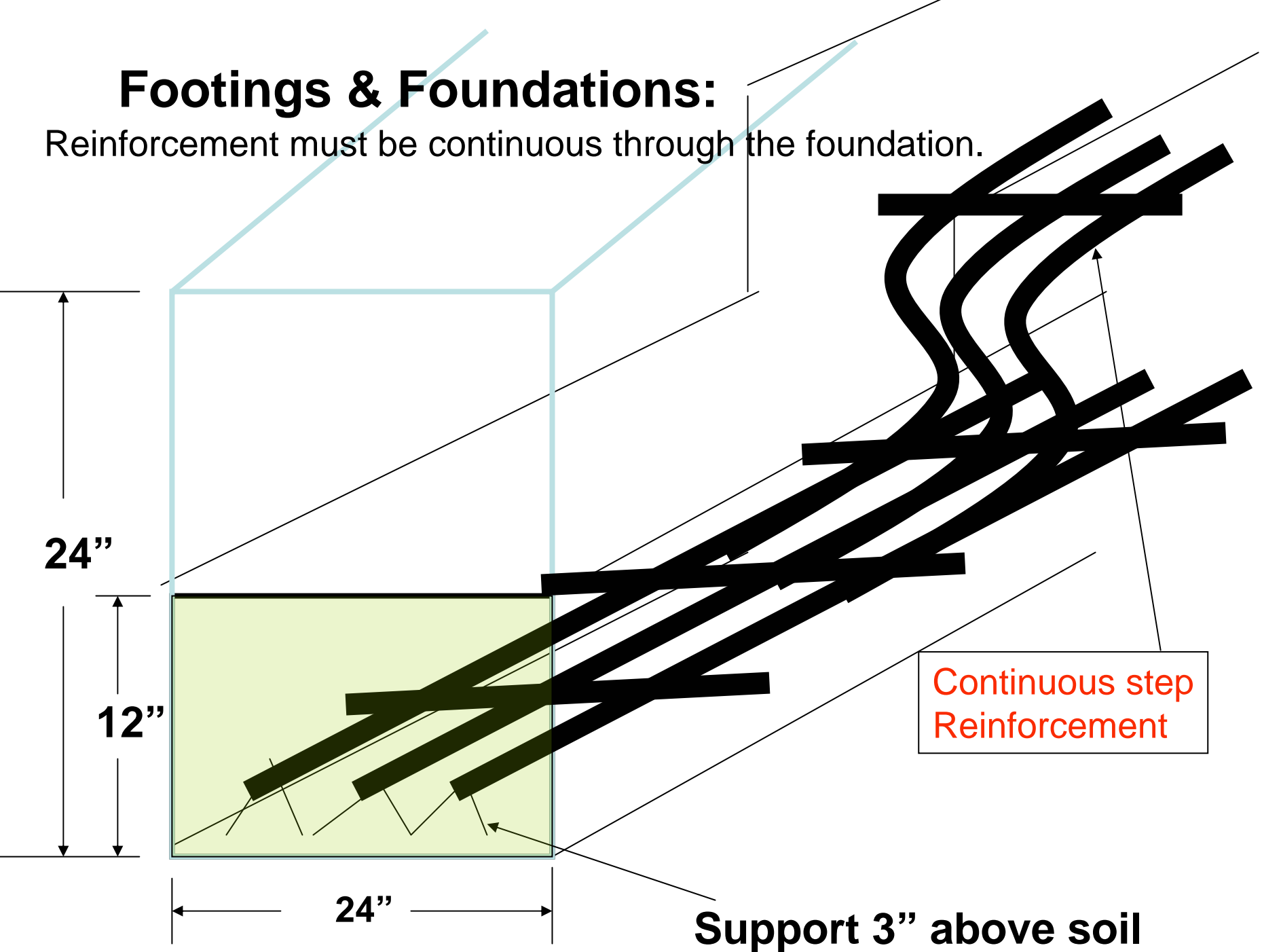
## Fayetteville minimum requirements

These are the minimum by City Ordinance. For alternatives, consult a design professional or foundation specialist.



# Footings & Foundations:

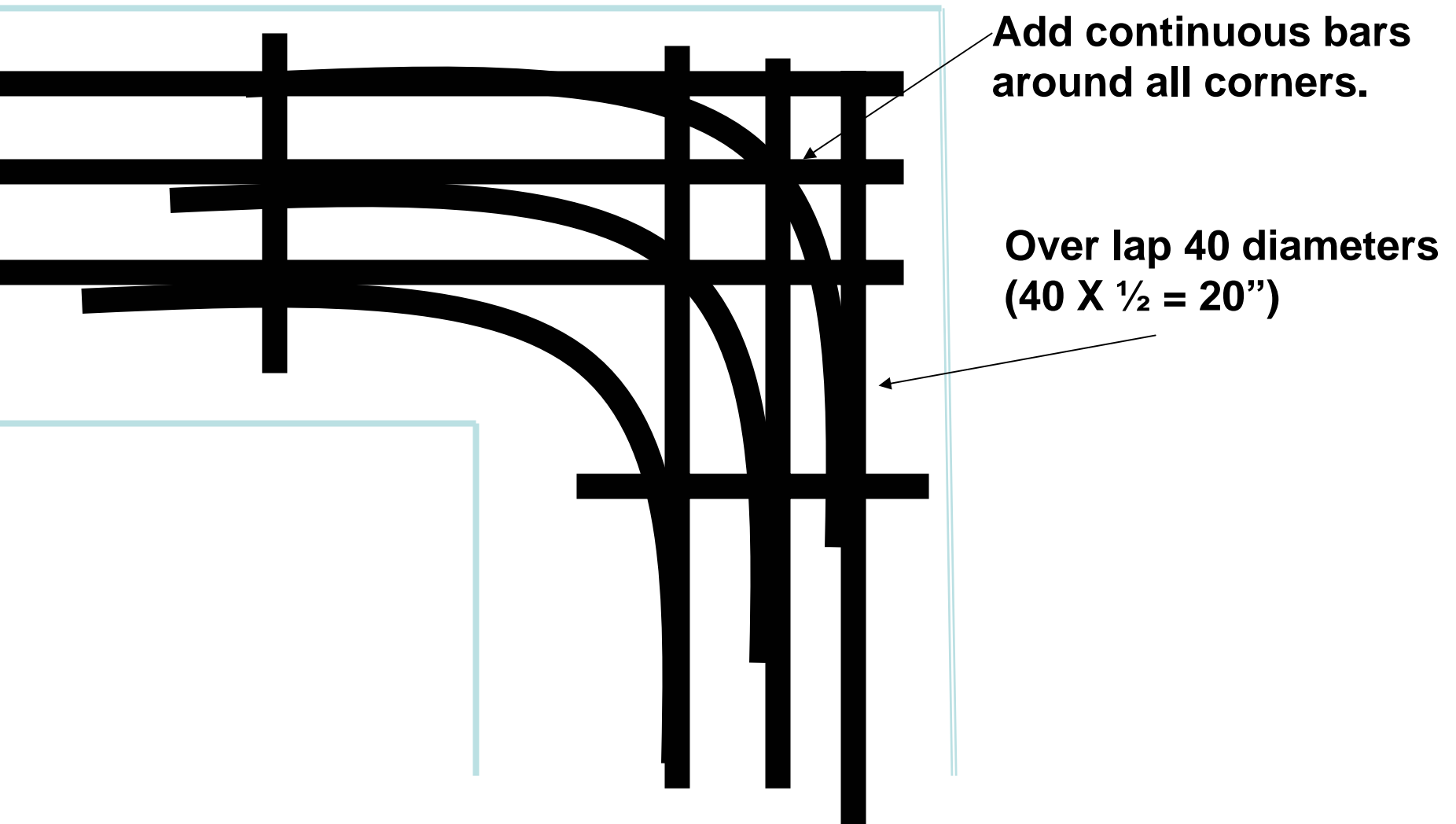
Reinforcement must be continuous through the foundation.



# Footings & Foundations:

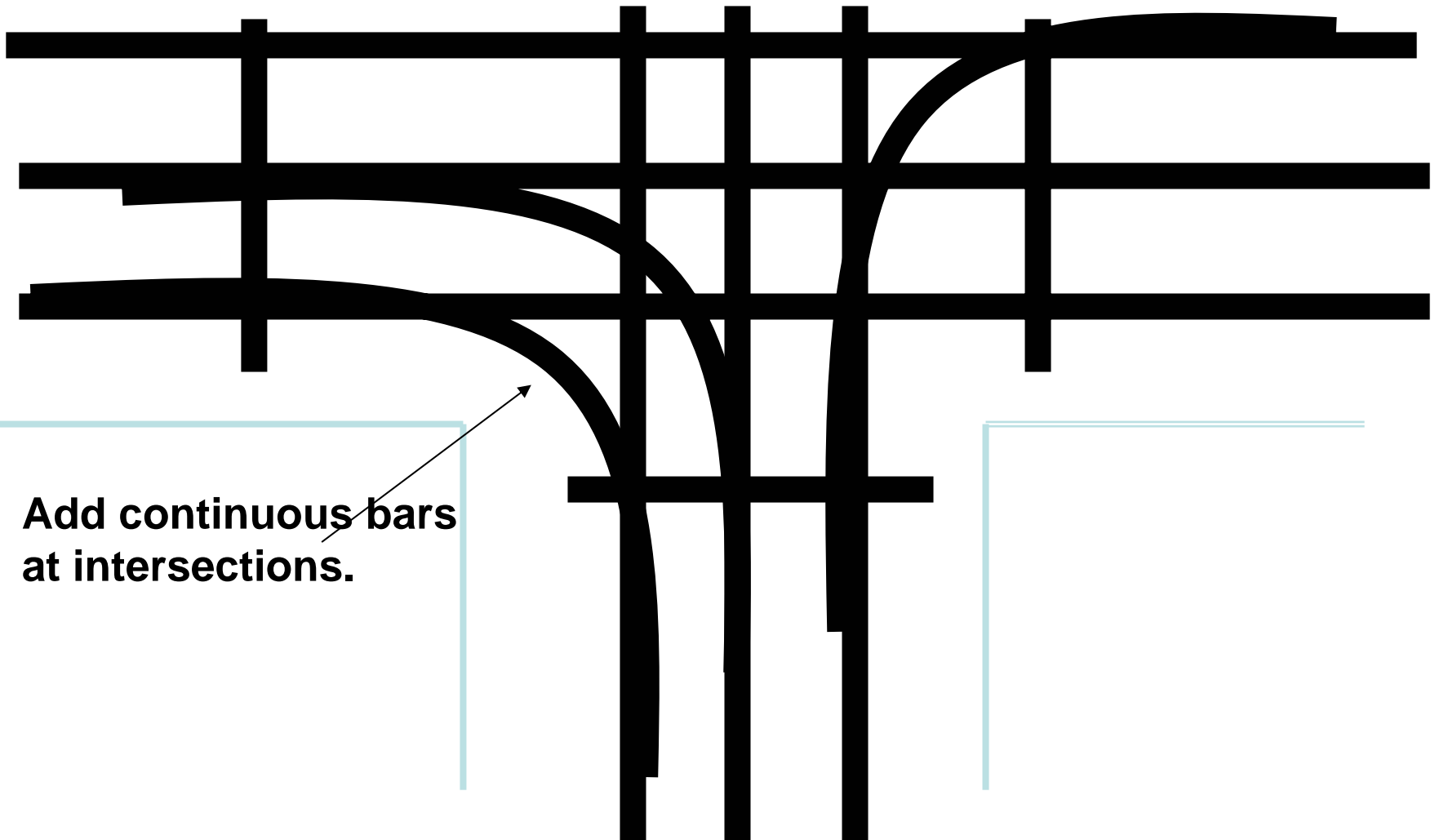
Reinforcement must be continuous at corners.

Overlaps must be long enough to transfer the loads.



# Footings & Foundations:

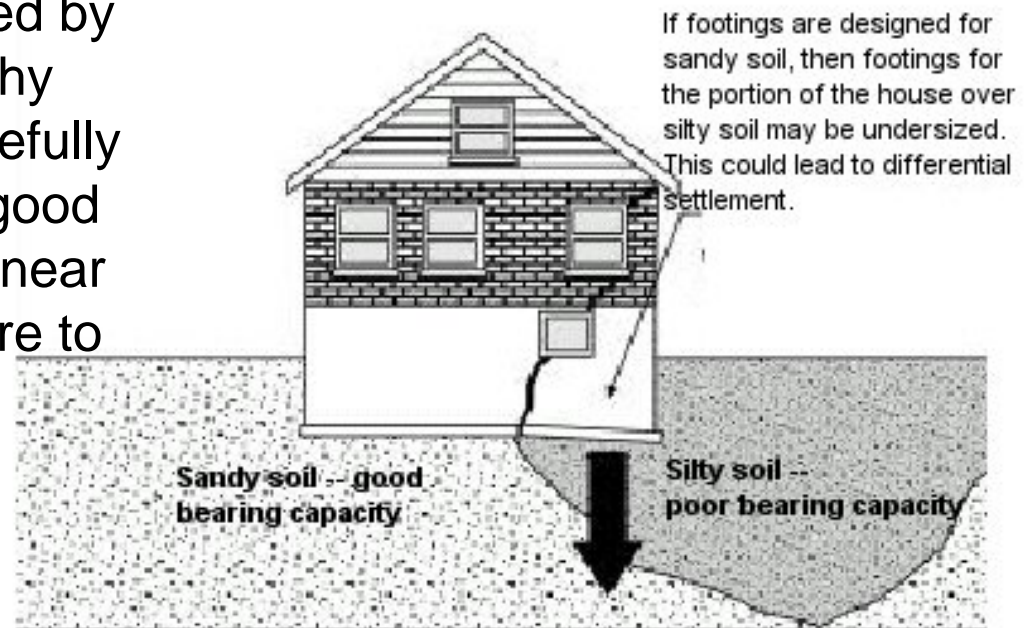
Reinforcement must be continuous at all intersections.



**Add continuous bars  
at intersections.**

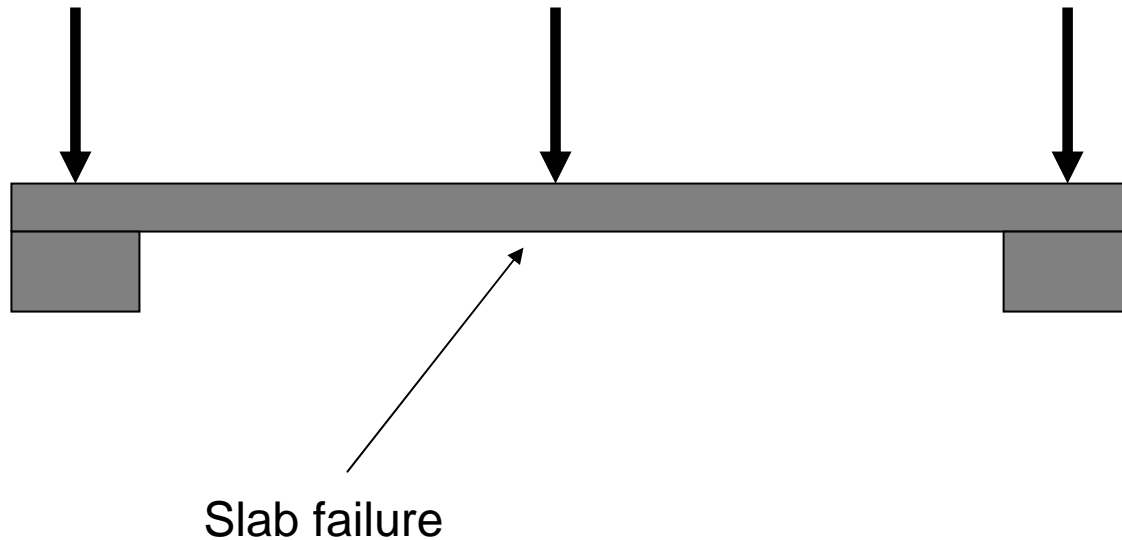
# Footings & Foundations: Differential Settlement

Differential settlement is the greatest problem presented by expansive soils. That's why it's important to watch carefully during excavation. It's a good practice to dig a test hole near each corner of the structure to check soil conditions.



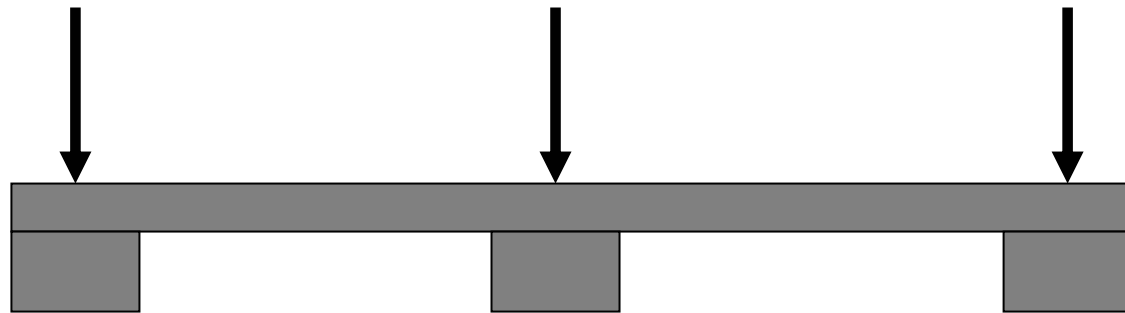
# Footings & Foundations: Differential Settlement

Differential settlement is also a problem for interior supporting slabs and foundations.



# Footings & Foundations: Differential Settlement

Remedy by providing foundations at all load bearing points.



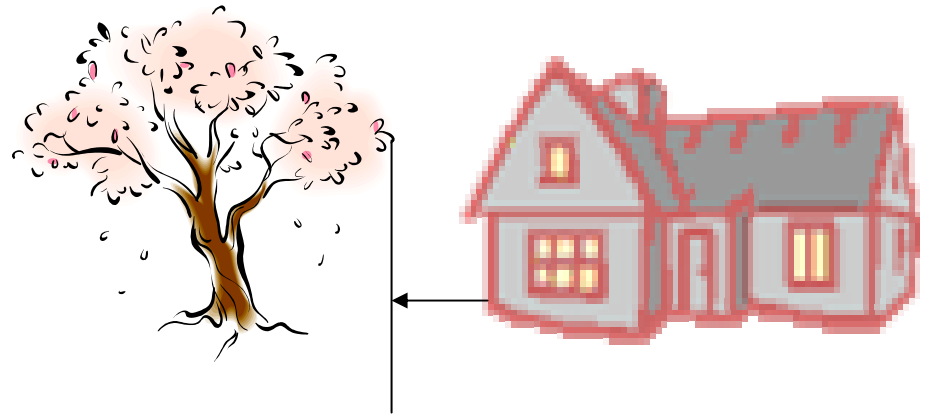
# Footings & Foundations :

## Landscaping

### Trees

Trees can cause problems for nearby foundations in three primary ways:

- By physical contact with the foundation.
- By affecting the moisture content of the soil under or near a foundation.
- By causing air gaps and shifting soil due to decaying roots under or near a foundation (when a tree dies or is removed).



The drip line of any tree should not be in the foundation area.



# Footings & Foundations :

## Landscaping

### Trees

Consider the full grown size of any trees or large shrubs to be planted near the structure.



The drip line of any tree should not be in the foundation area.

# Drainage:

**“Controlling water drainage is the most cost effective means of lessening adverse effects to a structure due to soil volume changes (expansion & contraction).”**



Water movement can have disastrous results on a foundation system.

Water not only moves across the surface but also within the soils. This movement through the soils results in “hydrostatic pressure”.

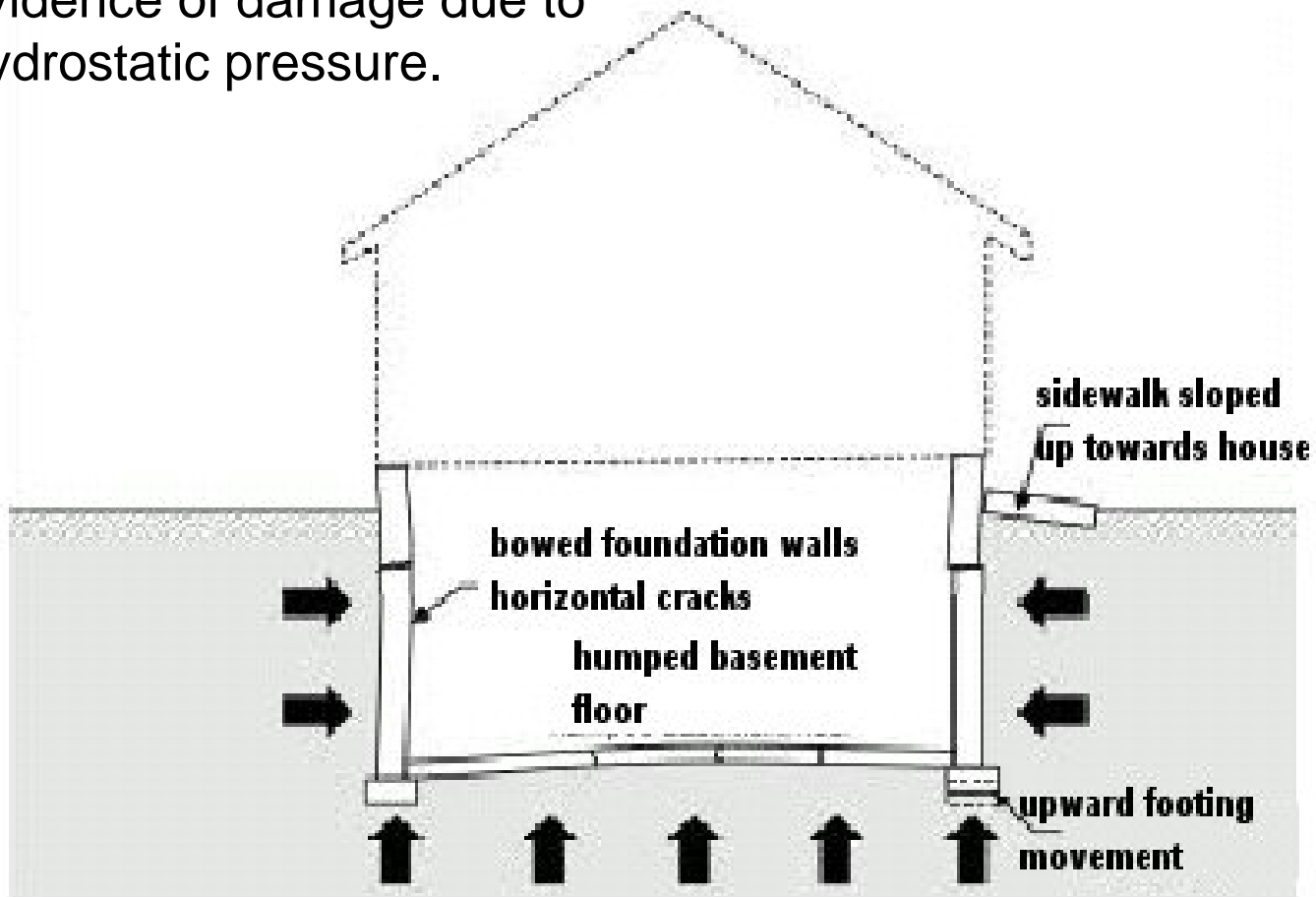
Hydrostatic pressure is found where a structure is located on a hillside or a valley. Water enters from above and travels through the soil until it reaches an aquifer or it is disrupted by something like a foundation.

That is why it's essential to provide a system for the water to escape without creating a hazard.

# Drainage:

## Hydrostatic pressure

Evidence of damage due to Hydrostatic pressure.

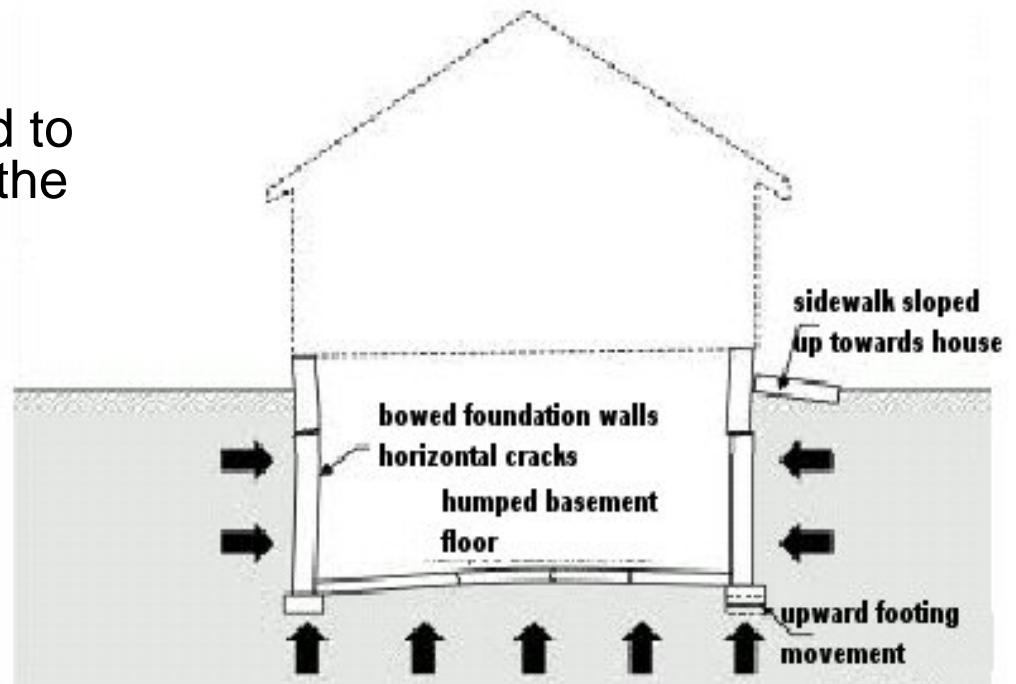


# Drainage:

## Hydrostatic pressure

**Hydrostatic pressure** is placed on the foundation and slab where water enters the earth above the structure and moves through the earth.

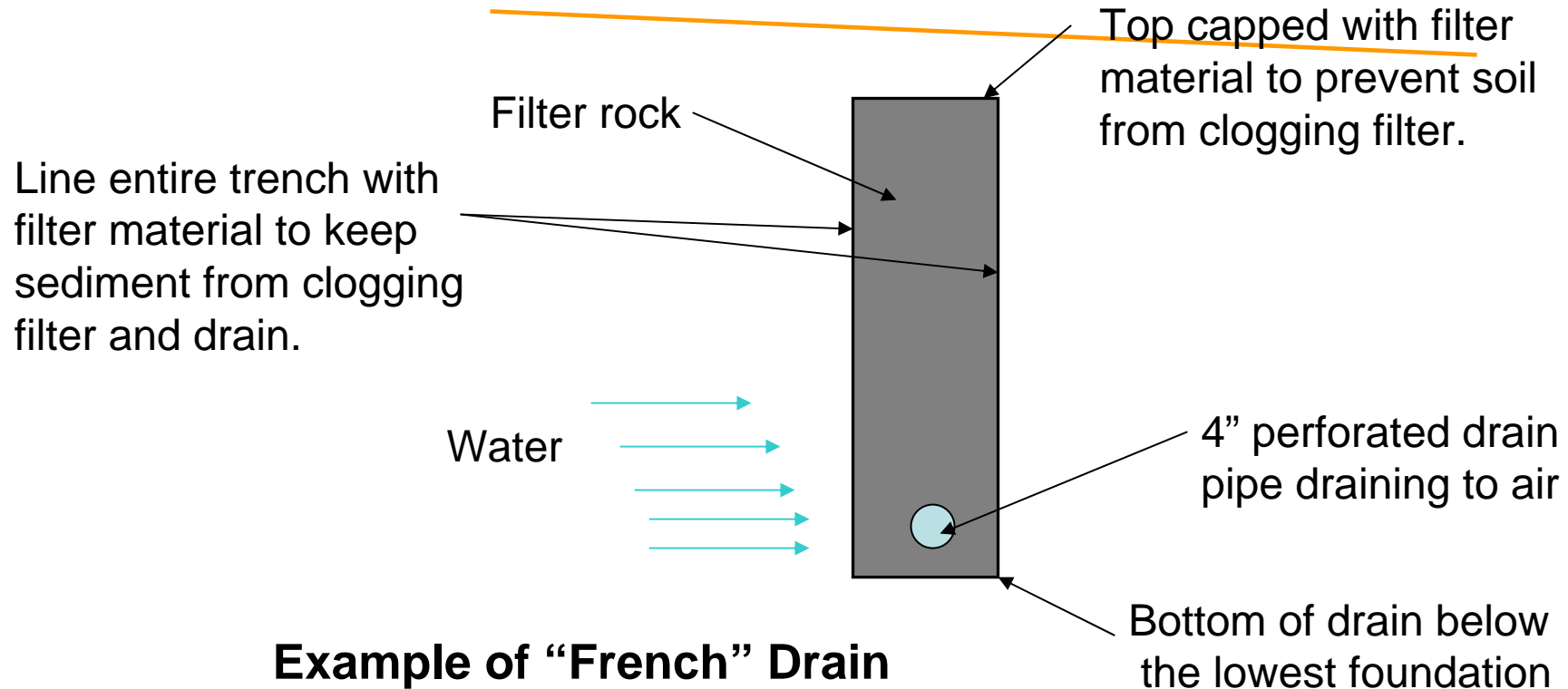
A drainage system is required to relieve this pressure from the structure.



# Drainage:

## Hydrostatic pressure

It is essential to provide a drainage systems to capture the water moving through the earth and relieve hydrostatic pressure.

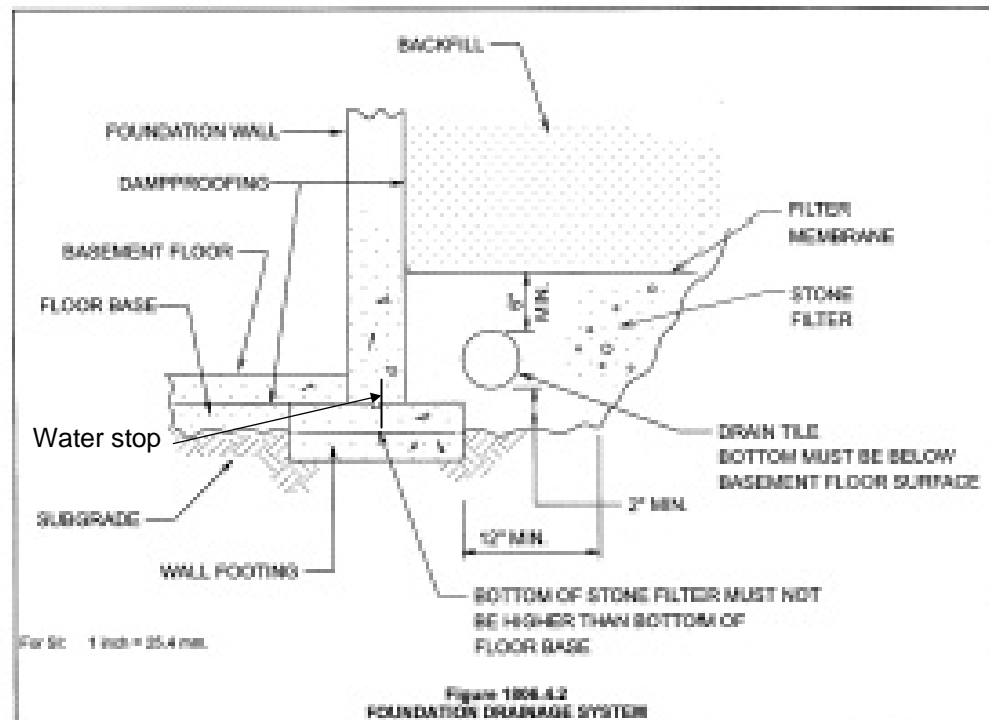


# Drainage:

## Hydrostatic pressure

**A permit is required for retaining walls greater than 4 ft in height. Engineering reviews these permits for proper design and drainage.**

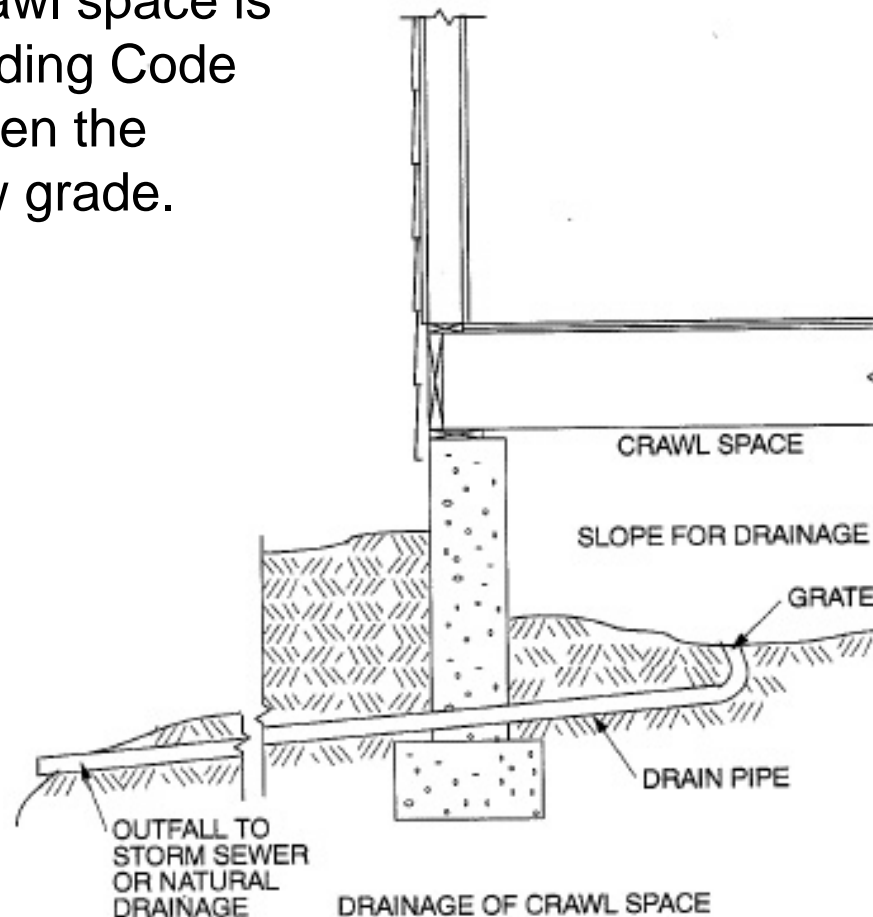
Retaining walls located outside and stem walls that support a structure both need drainage systems to relieve hydrostatic pressure.



# Drainage:

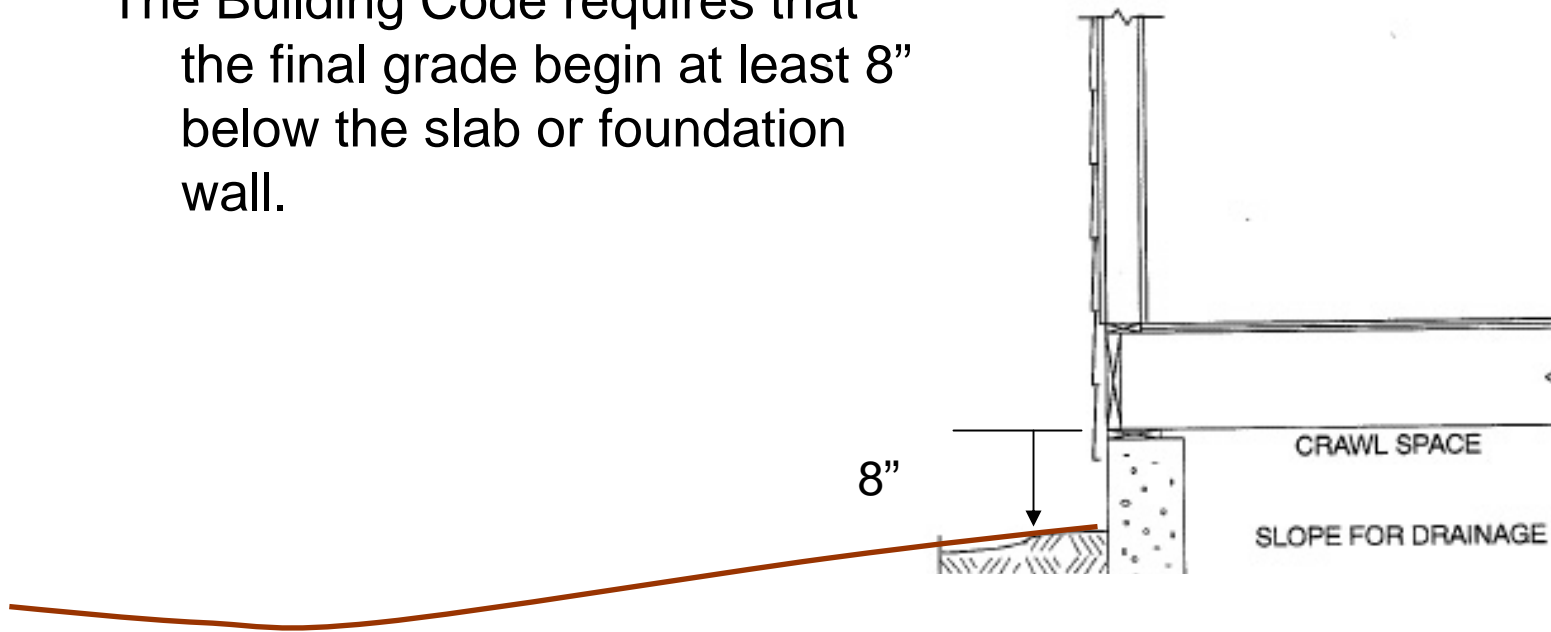
## Hydrostatic pressure

Drainage inside the crawl space is required by the Building Code to remove water when the crawlspace is below grade.



# Drainage: Surface water

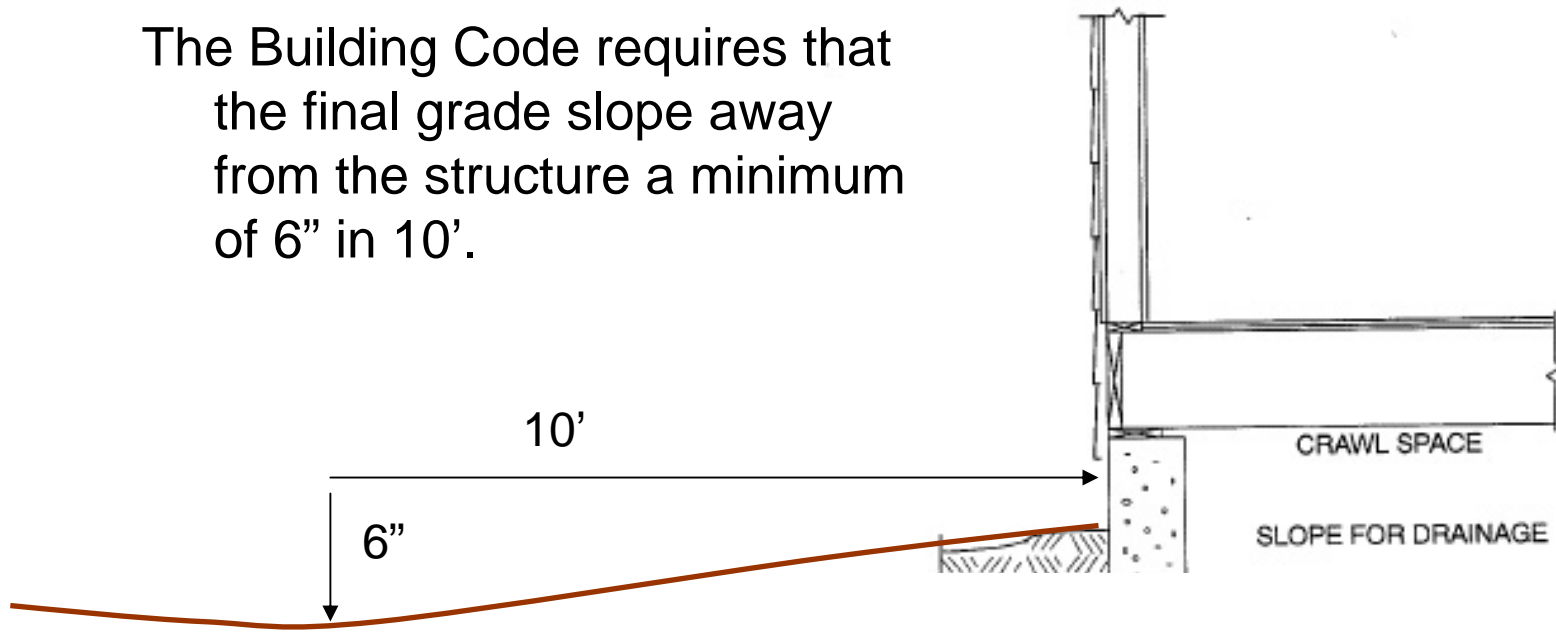
The Building Code requires that the final grade begin at least 8" below the slab or foundation wall.





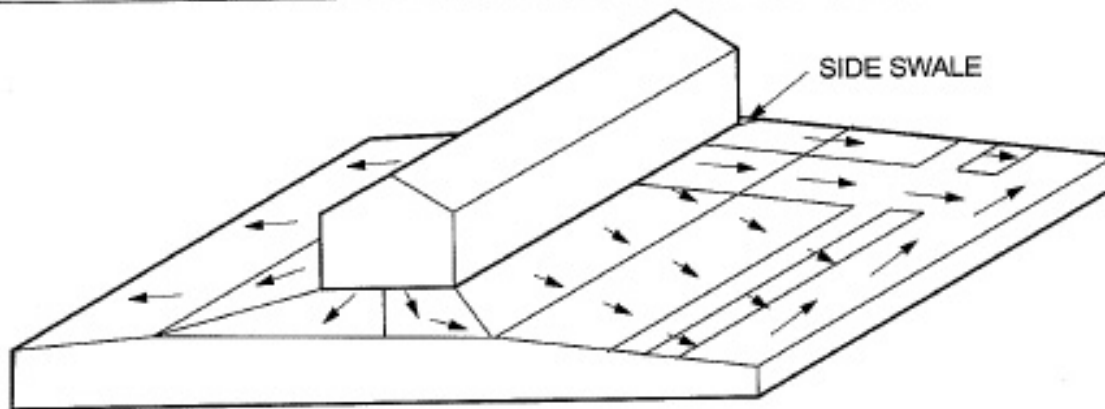
# Drainage: Surface water

The Building Code requires that the final grade slope away from the structure a minimum of 6" in 10'.



# Drainage: Surface water

The Building Code requires that water must be diverted away from the structure.

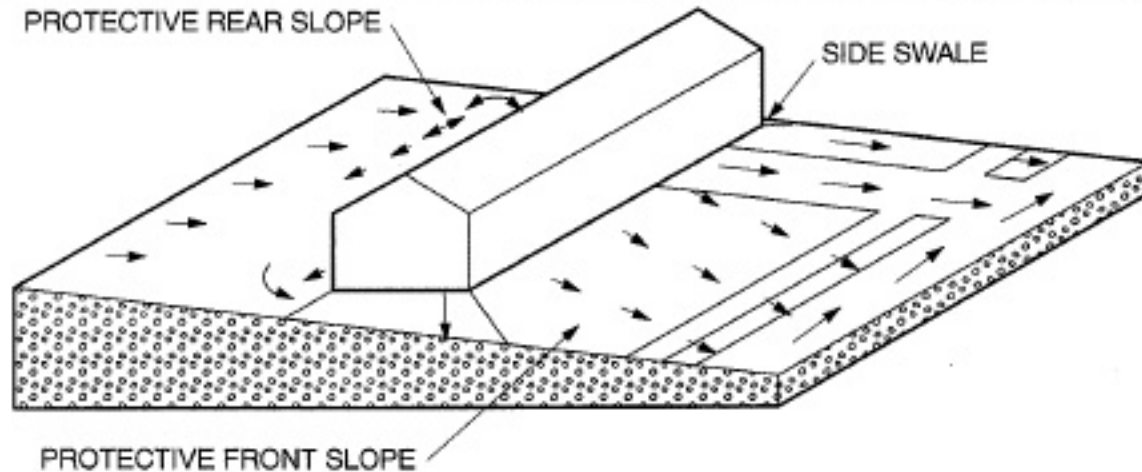


GRADING METHOD FOR LOT WHERE DWELLING IS LOCATED ON A RIDGE.  
DRAINAGE SWALES ARE LOCATED AT SIDE YARDS IN AREA OF POSITIVE SLOPES.

Figure R401.3(2)  
LOT GRADING EXAMPLE

# Drainage: Surface water

Special care must be taken to divert water away from the structure on slopes.



GRADING METHOD FOR LOT WHERE SLOPE IS FROM REAR TO FRONT LOT.  
DRAINAGE SWALES ARE LOCATED AT REAR AND SIDES OF DWELLING.

**Figure R401.3(1)**  
**LOT GRADING EXAMPLE**

# Drainage:

## Surface water

The Building Code requires slabs and foundations to be a minimum height above the point of collection for surface water so “not to cause a hazard”. That means that water cannot be left standing or create a hazard on adjoining property.

12" + 2% grade between top of slab or foundation to the drainage point of collection.

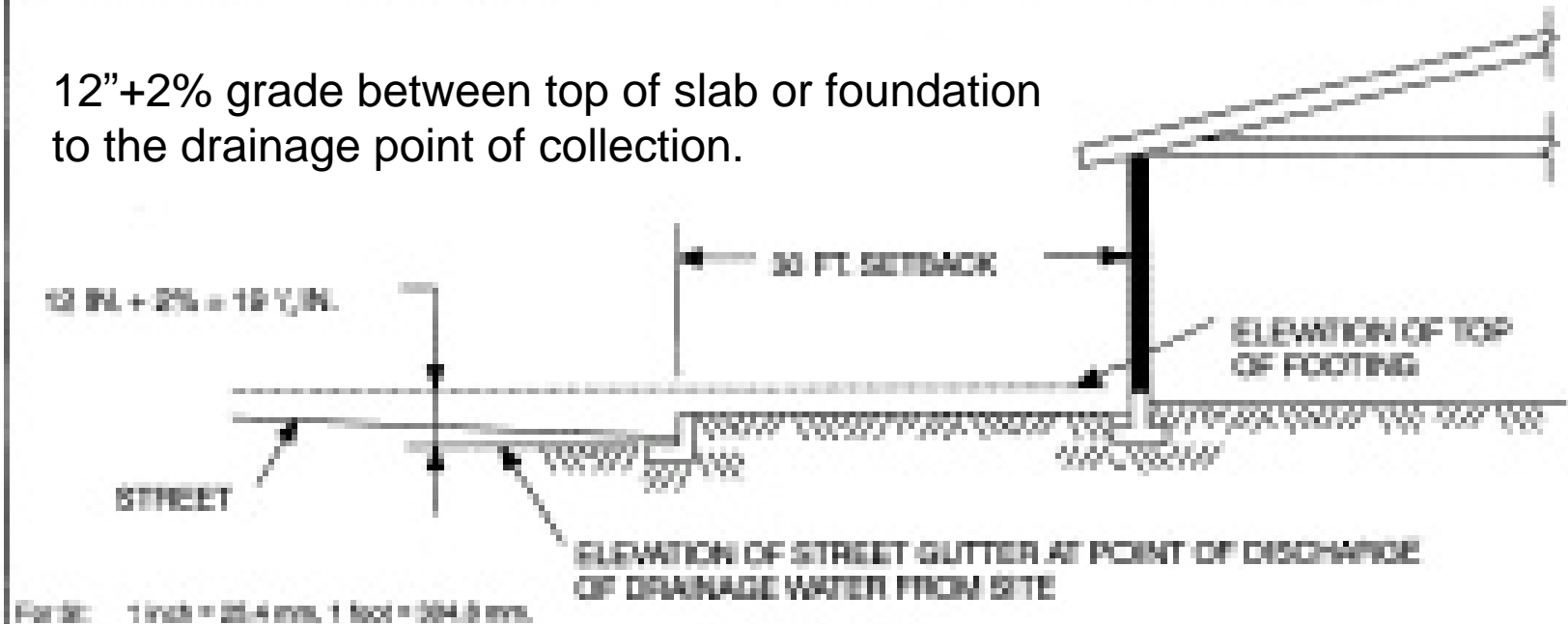
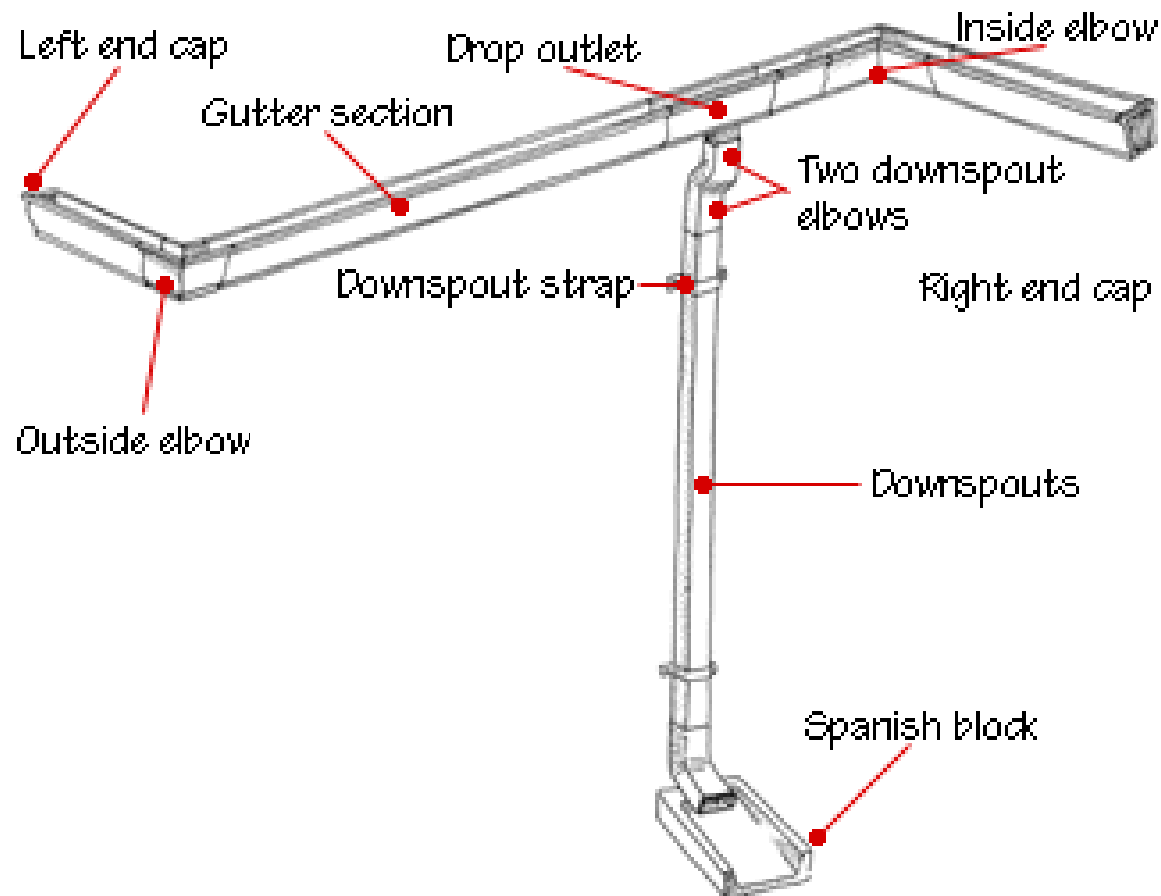


Figure 1805.3.4  
FOOTING ELEVATION ON GRADED SITES

# Drainage:

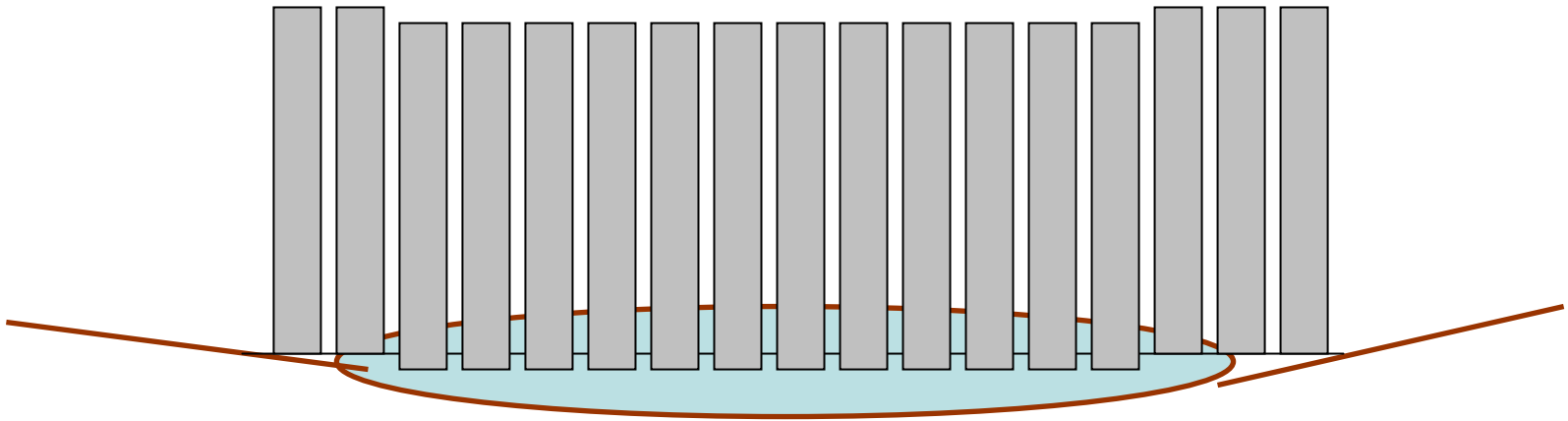
## Surface water

Roof gutters should be installed and connected to a separate drainage system to carry water away from the structure.



# Drainage: Surface water

Do not block drainage with fences or other structures.



Provide a depression in the sidewalk to allow water to pass.



# **Compaction:**

## **Materials supporting structures**

### **Compacted fill material.**

An approved report is required where footings will bear on compacted fill material.

The Building Code requires a report from a design professional that includes the following

1. How the site is prepared for the placement of compacted fill materials.
2. Which materials are to be used as compacted fill.
3. What test method to be used to determine the maximum dry density and optimum moisture content of the material.
4. The maximum allowable thickness of each lift.
5. The type of field test method for determining the density of the compacted fill.
6. The minimum acceptable density expressed as a percentage.
7. The number and frequency of field tests required to determine compliance.

**EXCEPTION:** Compacted fill material less than 12 inches (305 mm) in depth need not comply with an approved report, provided it has been compacted to a minimum of 90 percent Modified Proctor in accordance with ASTM D 1557.

The compaction shall be verified by the inspector.

# Compaction:

## Materials supporting structures

Soil analysis of fill materials are preformed at test laboratories.

Most fill materials from suppliers have been tested.

Ask supplier for soil analysis of the material used then consult a professional for compaction and lift specifications.

### Classification of Soils For Engineering Purposes (Unified Soil Classification System)

Job Number: FY053472

Date: 30-Sep-05

Project:

Stephens Pit

Sample Number:

1

Sample Identification:

Fine Grit

Description of Sample:

White Clayey Sand

Moisture Content: 17.7

Atterberg Limits:

USC : SC

Liquid Limit :

AASHTO : A-4 (0)

Plastic Limit :

Plasticity Index :

Nonplastic

| Sieve Size                 | 3   | 3/4 | No. 4 | No. 10 | No. 40 | No. 200 |
|----------------------------|-----|-----|-------|--------|--------|---------|
| Percent Retained           | 0.0 | 0.0 | 11.3  | 31.1   | 50.6   | 63.0    |
| Percent Passing            | 100 | 100 | 88.7  | 68.9   | 49.4   | 37.0    |
| Specifications - % Passing |     |     |       |        |        |         |



# Compaction:

## Materials supporting structures

Each lift must be tested to verify that the desired moisture content and compaction ratio is achieved. These reports must be available to the Inspector so he can verify the compaction has been achieved.

### NUCLEAR DENSITY REPORT ASTM D 2922

|                   |                            |  |                        |        |  |            |        |  |             |           |           |  |
|-------------------|----------------------------|--|------------------------|--------|--|------------|--------|--|-------------|-----------|-----------|--|
| PROJECT NAME:     | Stage Meadows Lots 40 & 41 |  | DATE:                  | 3/7/06 |  | TESTED BY: | R. Ott |  | START TIME: | 2:30 P.M. |           |  |
| REPORT NO:        | 0146044.001                |  | CLIENT:                |        |  |            |        |  |             | END TIME: | 4:00 P.M. |  |
| PROJECT LOCATION: | Bayetteville, Arkansas     |  | CLIENT REPRESENTATIVE: |        |  |            |        |  |             | MILEAGE:  | 8 miles   |  |

| PROCTOR ID | DESCRIPTION       |  | Test Method | USCS | LL, PI | MAXIMUM DRY DENSITY | OPTIMUM MOISTURE CONTENT |  |
|------------|-------------------|--|-------------|------|--------|---------------------|--------------------------|--|
| 1          | Red Clayey Gravel |  | D698        | GC   | 48.25  | 99.6                | 25.4                     |  |
|            |                   |  |             |      |        |                     |                          |  |
|            |                   |  |             |      |        |                     |                          |  |


  

| Test Number | Proctor L.D. | Elevation | Depth of Test (in) | Wet Density, lbs./cu.ft. | Field Moisture % | Dry Density, lbs./cu.ft. | In Place Compaction (%) | Compaction Required (%) |
|-------------|--------------|-----------|--------------------|--------------------------|------------------|--------------------------|-------------------------|-------------------------|
| 1           | 1            | Subgrade  | 8                  | 116.1                    | 14.5             | 101.4                    | 101.8%                  | 95                      |
| 2           | 1            | Subgrade  | 8                  | 111.3                    | 12.8             | 98.6                     | 99.0%                   | 95                      |
| 3           | 1            | Subgrade  | 8                  | 117.1                    | 17.0             | 100.1                    | 100.5%                  | 95                      |
| 4           | 1            | Subgrade  | 8                  | 113.9                    | 16.3             | 98.0                     | 98.4%                   | 95                      |
|             |              |           |                    |                          |                  |                          |                         |                         |
|             |              |           |                    |                          |                  |                          |                         |                         |
|             |              |           |                    |                          |                  |                          |                         |                         |
|             |              |           |                    |                          |                  |                          |                         |                         |

| Test Number | Location:   |
|-------------|---|
| 1           | Lot 41, 10 feet South and 20 feet East from Northwest corner of pad |
| 2           | Lot 41, 40 feet South and 40 feet East from Northwest corner of pad |
| 3           | Lot 40, 15 feet South and 5 feet East from Northwest corner of pad  |
| 4           | Lot 40, 30 feet South and 40 feet East from Northwest corner of pad |
|             |   |
|             |   |
|             |   |

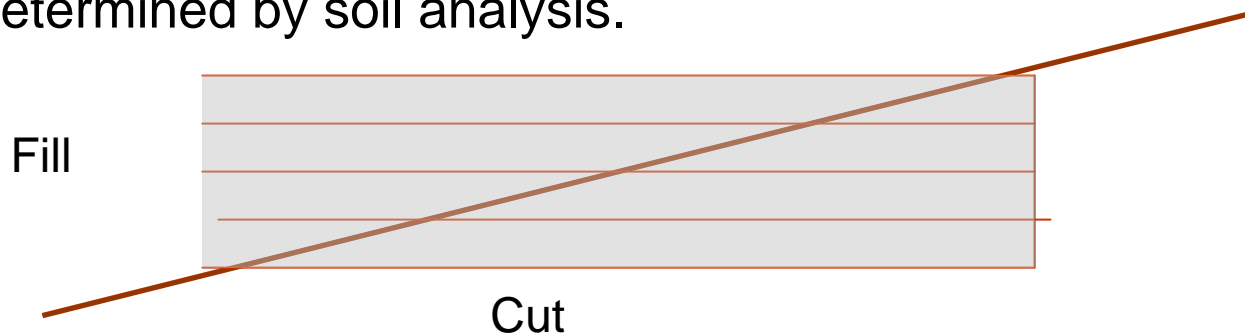
  



# Compaction: Materials supporting structures



Fill materials must be placed and compacted in lifts.  
The depth of the lift and the percentage of compaction  
Is determined by soil analysis.



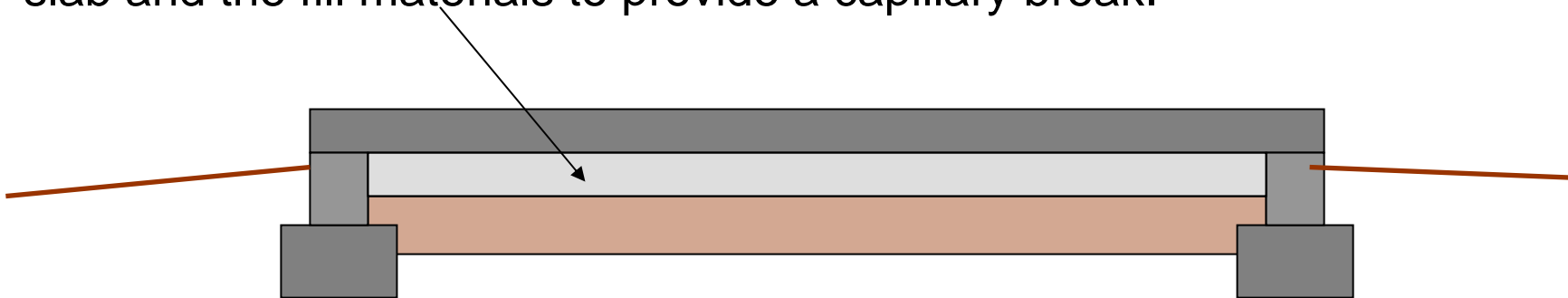
# Compaction:

## Materials supporting non-structural slabs

The Building Code requires that each lift be “consolidated to assure uniform support of the slab”.

Slab fill greater than 24” must meet the requirement of fill materials placed to support a structure.

A 4” layer of clean graded material should be used between the slab and the fill materials to provide a capillary break.



# **Compaction:**

## **Materials supporting non-structural slabs**

A well consolidated fill will support the load of a dump truck without any observed movement of the material. If any doubt, have the fill checked by an expert.



# **Best Practices Manual**

## **Footings & Foundations**

- Drainage**
- Compaction**

This document was created by the Fayetteville Building Safety Division with input from local builders, architects, engineers and foundation specialists.

Special thanks to:

James Burke  
Paul Gintonio  
Wayne Jones  
Gene O'Neal

For more information contact your Building Safety Division at 575-8233.

This manual is available at our office and on-line at: [www.accessfayetteville.org](http://www.accessfayetteville.org)